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Development of Problem-Based Learning Module on Trigonometry with an Orientation on Concept Understanding of High School Students

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ABSTRACT

This study aims to produce a problem-based learning module on trigonometry oriented towards the ability to understand concepts for grade X high school students and to describe the quality of the validity, practicality, and effectiveness of the module. This research is development research with the ADDIE development model, which includes five stages: analysis, design, development, implementation, and evaluation. The implementation of product development was carried out at the State Senior High School 1 Magelang, involving 36 students from class X MIPA 2. This research resulted in a trigonometry module based on problem-based learning syntax. The module is declared valid with an average assessment of material experts of 4.24 (valid) and media experts of 4.45 (valid). The module was displayed practical with the average student response questionnaire result of 3.93 (enough), the teacher's response questionnaire of 4.00 (practical), and the percentage of learning implementation of 95.24. Using the Minimum Completeness Criteria of 70, the module is declared effective with an average score of 80.72 for students' concept understanding, which is high, and the percentage of completeness is 87.88, which is good. Based on the hypothesis test with a significance level of 0.05, it shows that the average understanding of students' concepts is more than 70.

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INTRODUCTIONs

Mathematics is one of the subjects in formal schools taught from an early age. Mathematics is very closely related to counting, measuring and thinking systematically. Mathematics taught in primary and secondary education is commonly called school mathematics. The purpose of school mathematics was applied at every school level, where it related to facts and skills at the lower grade level. The middle grade is associated with concepts, and the high level is associated with principles (Sutawidjaja & Afgani, 2014, p. 15). This shows that mathematics is designed to be taught according to each school level.

Learning was a process of regulating the environment for students that aimed to grow and encouraged students to carry out the learning process(Pane & Dasopang, 2017). Mathematics learning is closely related to carrying out activities in the form of solving mathematical problems. Mathematics learning is carried out at several levels or levels. Mathematics learning is carried out at the Elementary School (SD), Junior High School (SMP), and High School (SMA) levels. Mathematics learning in schools is carried out with the principle of student-oriented or student-centred. Students are required to be active in finding information and developing the concepts they learn. In mathematics, students had to learn with understanding and actively build new knowledge from previous experiences and expertise

(NCTM, 2017, p. 2). This indicates that students need to understand the concepts they are learning following the stages of the flow of thinking at each level.

In fact, the mastery of Indonesian students in learning mathematics is still low. According to data from a survey conducted by the Program for International Student Assessment (PISA) for students aged 15 years, it showed that Indonesia is still in a low position. In 2018 Indonesia ranked 73 out of 78 participating countries (OECD, 2019, p. 18). The score of Indonesian students' mathematics learning outcomes was 379, and this result is still far from the international average score, which was 489. Similar results are also seen in the National Examination (UN) passing data published by the Ministry of Education and Culture of the Republic of Indonesia (2019) through the Assessment Center Education showed that the achievement of Indonesian students in learning mathematics was still low. The results of the national exam in mathematics for the junior high school level were recorded as having an average of 45.52. Then the Senior High School level of the Science Study Program had an average of 39.33, and the Vocational High School of 35.26. These data indicate that students' mastery of concepts in learning mathematics is still low.

One of the subjects taught at the 10th-grade high school level is trigonometry. Trigonometry studies trigonometric functions such as sine, cosine, tangent, cotangent, and cosecant and their relationships. Trigonometry was defined as the triangles study and the relationship between the sides and angles of the triangle (Sultan & Artzt, 2011, p. 153). Trigonometry is a new material for students studying at the high school level. Trigonometry is still considered a complex material for some students. This can be seen from the few students who correctly answered trigonometry questions in the National Examination organized by the Ministry of Education and Culture (Kemendikbud) of the Republic of Indonesia in 2019.

Table 1. Percentage of Students Answering Correctly the National High School Exam for the Science Study Program in 2019

No.	Tested Abilities	National Achievement
1.	Determining the value of a trigonometric ratio in various quadrants	21,89%
2.	Determining the graph of a trigonometric function	41,37%
3.	Solving contextual problems related to the sine rule and/or cosine rule	42,04%
4.	Solving problems related to cosine rule	28,09%

It can be seen from table 1 that the percentage of students at the high school level of the science study program answered the exam questions with indicators of solving problems. It related to the cosine rule was 28.09 (Kemendikbud, 2019). This can mean that the number of students who can correctly answer questions on the indicators of solving problems related to the cosine rule is only 28.09% of the total high school students in the Science Study Program group who took the exam that year. The other abilities tested related to trigonometry also showed low results; the achievement obtained was still less than 55%.

Several things certainly influence the low learning achievement of Indonesian students. One of the factors is the students' low mastery of mathematical concepts. This is in line with research conducted by Azis & Sugiman, 2015), which stated that students still had some difficulty solving problems in test questions because they could not remember concepts that had been studied previously. An idea was an abstraction in the mind that was used to group similar things, events, ideas, objects or someone into one group (Woolfolk, 2016, p. 333). Mastery of concepts plays an essential role in learning mathematics. Concepts studied previously will be used to form new knowledge in the next lesson. This indicates that the ability to understand concepts is vital in learning mathematics.

Facilities and infrastructure influence the implementation of mathematics learning. Facilities and infrastructure were everything in the form of objects or things that were considered objects that would facilitate the process of activities either directly or indirectly to achieve a goal (Bussi & Borba, 2010; Santika et al., 2021). One of the facilities in learning is teaching materials. A teacher must be able to prepare suitable teaching materials so that the learning process can run according to the goals set in the curriculum. However, in reality, not many teachers have developed teaching materials independently. Research conducted by Setyadi & Saefudin, (2019) stated that teachers had not used their

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teaching materials but had used textbooks and Student Worksheets (*Lembar Kerja Siswa*). Similar results are also seen in Lasmiyati and Harta's research (2014), which revealed that schools had provided textbooks. However, the material taught was not under students' essential competencies, where cognitive aspects were still dominant and less contextual. This situation must be evaluated because the material taught to students does not always have to refer to books but must be adapted to the competencies that exist in the curriculum.

One of the alternative teaching materials that the teacher can develop is the module. The module was a learning material arranged in a clear, concise, and specific way to achieve a goal in learning (Lasmiyati & Harta, 2014). The module is arranged systematically into activities directed towards its goals. The module was an independent study material that aimed to enable students to learn independently, either with teacher guidance or not (Citroresmi & Suratman, 2016). This indicates that the module can train students to learn independently actively and does not always depend on the teacher's explanation. Modules as teaching materials have several advantages. Among the benefits is that the module comprises planned and directed activities so that student learning targets are clear. The module contains feedback and follow-up activities that students must carry out. The module is also equipped with questions and answer keys to be used as a guide for students to work on practice questions. By using the module, students will be actively involved in learning. Students were required to use critical thinking when obtaining material from what was conveyed by the teacher directly or from their learning outcomes (Citroresmi & Suratman, 2016). Therefore, the module will be practical when combined with a learning model that directs students to build their knowledge.

Problem-Based Learning (PBL) is a learning model where students are presented with issues at the beginning of learning to build knowledge. Problem-based learning involves case studies on authentic and meaningful issues so that students would solve and find solutions to these problems (Nelfiyanti & Sunardi, 2017). Students are required to explore solving existing issues actively. Problem-based learning provided opportunities for students to actively learned and develop a broader understanding (Delisle, 1997, p. 9). The use of modules with problem-based learning models is considered adequate, considering that there are still modules that do not meet the needs of students to achieve learning goals. This can be seen in the research conducted by previous researchers, namely Citroresmi & Suratman (2016). which only contained a summary, not accompanied by introductory illustrations or real-life problems.

Based on the description above, it is suspected that there are problems related to students' understanding of concepts in trigonometry material. These problems need to be addressed to support good learning in the future. Therefore, the learning module with a problem-based learning model can be used as an alternative to training students' conceptual understanding, especially in trigonometry material. This study aimed to produce a trigonometry module based on problem-based learning with an orientation on the ability to understand concepts of class X high school students and to describe the quality of the module in terms of validity, practicality, and effectiveness.

METHOD

The type of research conducted was research and development. Research and development was the research method used to produce the product and test its effectiveness of the product (Sugiyono, 2018). The product developed was a trigonometry module with a problem-based learning model for 10th-grade high school students. Product quality assessment was based on the evaluation of learning products, according to Nieveen (1999), including validity, practicality, and effectiveness.

We conducted research at State Senior High School 1 Magelang, Central Java. The experimental subjects in this study were 36 students of the 10th grade MIPA 2 study program at State Senior High School 1 Magelang. The module product trial implementation started from May 5, 2021, to May 19, 2021. Allocations for product trials were four meetings with details of 3 sessions for learning activities and one discussion for learning outcomes tests (post-test) and filling out response questionnaires for students.

Procedure

The development model used in this study is the ADDIE development model. The ADDIE development model was developed by Dick & Carey (1996) and consisted of five stages: Analysis, Design, Development, Implementation, and Evaluation. At the analysis stage, the researcher carried out

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the main activities to determine the need to develop learning modules. The analysis includes several things, including requirements, curriculum, and student character analysis. A needs analysis was carried out by digging up information about problems related to teaching materials in learning. Curriculum analysis was carried out by analyzing essential competencies, materials, and indicators of competency achievement. Analysis of student character was done by analyzing student character through observation, relevant studies, and supported by interviews with high school mathematics teachers.

The design stage was the creation of a modular design based on the results of the analysis. The method was carried out by including designing the module framework, material items to be presented, concept maps, references to be included in the module, and module assessment instruments. The assessment instrument consisted of a module comprised of questionnaires and tests which were prepared by taking into account the aspects of the feasibility of the content, conformity with the problem-based learning model, presentation, language, and graphics. The questionnaire instrument consisted of a material expert validation sheet, a media expert validation sheet, a student response questionnaire, and a teacher response questionnaire. The test instrument was in the form of a conceptual understanding test.

The development stage was the preparation of the trigonometry module with a problem-based learning model per the design that was made previously. The module made was validated by validators of material experts and media experts. The results of the validation as well as input and suggestions from experts, were used as a reference for improvement and refinement of the module before the module testing activities in learning.

The implementation phase was testing the module product in learning. In the learning process, the researcher acted as a teacher. At the same time, the class teacher served as an observer of the implementation of learning. At the last meeting of learning activities, student response questionnaires and learning outcomes tests were carried out to determine learning achievement using the developed module.

The last stage of development was the evaluation stage. The evaluation stage consisted of the main activities, namely the analysis of the trial results and the revision of the final stage of the developed module. The results of the analysis of the student and teacher response questionnaire data were used to determine the practicality of the module. Meanwhile, the results of data analysis on the conceptual understanding test were carried out to assess the level of effectiveness of the module. The final revision of the module was carried out based on the results of the student and teacher response questionnaires as well as input or suggestions from experts.

Data Collection Techniques

Data collection techniques used in this study were interviews, questionnaires, and test techniques. The interview technique was used for the initial analysis of development related to material analysis, curriculum analysis, and student character analysis. Interviews were conducted with 10^{th}-grade high school mathematics teachers. A questionnaire technique was used to obtain responses related to the validity and practicality of the module. Meanwhile, the test technique was used to determine the level of effectiveness of the module.

The form of data in this study consisted of test and non-test data. The test data were obtained from the module effectiveness instrument. The non-test data were obtained from the instrument's validity and practicality. The instrument of validity consisted of a validation questionnaire of material experts and media experts. The material expert and media expert validation questionnaire consisted of statement items with five alternative answers using a Likert scale, namely a score of 5 (very good), a score of 4 (good), a score of 3 (enough), a score of 2 (less), and a score of 1 (very poor). Three material experts and two media experts assessed the module product. The material experts for the resulting module products were 2 Mathematics Education lecturers and 1 Mathematics teacher, while the media experts were 2 Mathematics Education lecturers. The material and media expert assessment sheets were prepared with modifications based on the assessment standards for learning textbook products by the Ministry of Education and Culture. Tables 2 and 3 below present aspects and indicators of expert assessment on instrument validity.

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Table 2. Aspects of Validity Assessed by Material Experts

No.	Aspect	Indicators
1.	Content Eligibility	1. Material compatibility with the Curriculum
		2. Material accuracy
		3. Systematic presentation
		4. Up-to-date material
		5. Language accuracy
2.	Compatibility with Problem-Based Model Learning	1. Use of real context
		2. Include a sample of problems
		3. Problem-solving activities
		4. Student activeness
		5. Syntax accuracy of problem-based learning

Table 3. Aspects of Validity assessed by Media Experts

No.	Aspect	Indicator
1.	Eligibility in presenting the material	1. Content quality
		2. Presentation technique
		3. Completeness of module components
		4. Readability
2.	Language eligibility	1. Conformity with the Indonesian language rules
		2. Conformity to student's level of development
		3. Communicative language
3.	Graphic Eligibility	1. Module size
		2. Module cover design
		3. Module content design

Practical instruments consisted of student response questionnaires, teacher response questionnaires, and learning implementation observation sheets. The student and teacher response questionnaire consisted of statement items with five alternative answers using a Likert scale, namely a score of 5 (strongly agree), a score of 4 (agree), a score of 3 (neutral), a score of 2 (disagree), and a score of 1 (strongly disagree). The assessment aspects of this response questionnaire included presentation, content, language, graphics, and benefits. This response questionnaire was filled in after the learning activities using the module had been completed. Meanwhile, the learning implementation observation sheet consisted of statement items with alternative answers "Yes" and "No". The observer filled out this sheet during the learning activity. Table 4 presents the aspects and indicators of the practicality of the module questionnaire instrument assessment.

Table 4. Practical Aspects Assessed by Students and Teachers

No.	Aspect	Indikator
1.	Presentation	1. Completeness of learning units
		2. Continuity of learning flow
2.	Content	1. Clarity of material concept
		2. Conformity of practice question
		3. Formative test conformity
3.	Language	1. Simple and easy-to-understand language
		2. Language consistency
4.	Graphics	1. Suitability of the cover
		2. Existence of illustration or picture
		3. Clarity of the display module
5.	Benefits	1. Ease of understanding the concept of material
		2. Interest in learning the material

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The module effectiveness instrument was in the form of a conceptual understanding test. The concept understanding test consisted of 10 descriptive questions. These questions were answered by students at the end of the learning activity using the developed module. The test questions were arranged based on indicators of conceptual understanding. Table 5 presents indicators of concept understanding used in the module effectiveness instrument (adapted from Kemendikbud (2014)).

Table 5. Indicators of Concept Understanding on Effectiveness Instrument

No.	Concept Understanding Indicators
1.	Restating a mathematical concept
2.	Classifying objects according to specific properties
3.	Making an example and not an example
4.	Presenting concepts in various forms of mathematical representations
5.	Applying a problem-solving concept or algorithm

Data Collection Techniques

The data analysis technique used was descriptive data analysis and inferential data analysis. Data analysis was conducted to determine the quality of the module in terms of validity, practicality, and effectiveness. Data related to the average assessment score for each instrument which includes a material expert validation questionnaire, media expert validation questionnaire, student response questionnaire, teacher response questionnaire, and concept understanding test, were converted into qualitative data with reference criteria according to (Sudjana, 2019, p. 118) as presented in Table 6.

Table 6. Rating Conversion Guidelines

Score Percentage	Classifications
$\bar{X} \geq 90\%$	Excellent
$80\% \leq \bar{X} < 90\%$	Very Good
$70\% \leq \bar{X} < 80\%$	Good
$60\% \leq \bar{X} < 70\%$	Fair
$0\% \leq \bar{X} < 60\%$	Poor

Information:
$\bar{X}$ = average score of the assessment

Validity data analysis was carried out on material and media experts' validation questionnaires. The steps taken related to the validity of data analysis were calculating the assessment score of each expert, calculating the average score for all experts, and converting the average score into a qualitative value with the reference criteria in Table 6 with a maximum score of 5 and a minimum score of 1. Therefore, the module validity criteria guidelines were then obtained in Table 7. The module is declared valid and feasible if the average expert assessment score meets the minimum, good criteria.

Table 7. Guidelines for Validity Criteria

Score Range	Criteria
$4{,}5 \leq \bar{X} \leq 5$	Excellent validity
$4 \leq \bar{X} < 4{,}5$	Very Good validity
$3{,}5 \leq \bar{X} < 4$	Good validity
$3 \leq \bar{X} < 3{,}5$	Low validity
$0 \leq \bar{X} < 3$	Very low validity

Practical data analysis was carried out on student and teacher response questionnaires. The steps taken regarding the practicality data analysis were the same as the validity data analysis. The module is declared practical if the average score obtained meets the minimum criteria, which is relatively reasonable. The guidelines for the conversion of assessments on the practical aspect are shown in Table 8. Meanwhile, data analysis of the learning observation sheet was carried out to see the implementation

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of learning with the problem-based learning model. The steps in data analysis on the learning observation sheet were (1) tabulation of data where a score of 1 is for the "Yes" option, and a score of 0 is for the "No" option and (2) calculation of the percentage of learning implementation by counting the number of answers to the "Yes" statement then divided by the number of statements multiplied by one hundred per cent.

Table 8. Practical Criteria Guidelines

Average Score	Criteria
$4{,}5 \leq \bar{X} \leq 5$	Very Practical
$4 \leq \bar{X} < 4{,}5$	Practical
$3{,}5 \leq \bar{X} < 4$	Rather Practical
$3 \leq \bar{X} < 3{,}5$	Impractical
$0 \leq \bar{X} < 3$	Very Impractical

Effectiveness data analysis was carried out on the student's conceptual understanding of test results. The steps taken related to the effectiveness of data analysis were calculating the assessment score of each student, calculating the average student score, and converting the average score into a qualitative value with the assessment criteria referring to Table 6 with a maximum score of 100 and a minimum score of 0. Therefore, the criteria guidelines for students' conceptual understanding ability in Table 9 could be obtained.

Table 9. Criteria of conceptual understanding ability

Score range	Criteria
$90 \leq \bar{X} \leq 100$	Very High
$80 \leq \bar{X} < 90$	High
$70 \leq \bar{X} < 80$	Rather High
$60 \leq \bar{X} < 70$	Low
$0 \leq \bar{X} < 60$	Very Low

After obtaining the data on the average students' concept understanding score, the percentage of students' learning completeness was determined. The students' completeness criteria in this study were based on the Minimum Mastery Criteria set by the school, which is 70. The following steps calculated the percentage of learning completeness: (1) counting the number of students who completed learning (met the minimum score of mastery criteria), (2) calculating the percentage of complete learning obtained by counting the number of students who completed learning divided by the number of students who took the test multiplied by one hundred, and (3) converting the percentage of learning completeness into qualitative values based on the reference criteria in Table 6.

After using problem-based learning modules, the data analysis was then carried on to the inferential analysis stage to determine the criteria for students' conceptual understanding abilities. The data on the results of the conceptual understanding test were analyzed using the SPSS 25 software. The module developed was said to be effective if the average student understood the concept more than 70. The formulation of the hypothesis tested in this study was as follows.

H_0:$\mu \leq 70$ (The average ability of students' conceptual understanding is not more than 70)

H_1:$\mu > 70$ (The intermediate knowledge of students' conceptual understanding is more than 70)

Before testing the hypothesis, the assumption of normality must be met first. The test results data were tested to determine whether the data were normally distributed or not. This test was carried out with the help of SPSS with the statistic of the One-Sample Kolmogorov-Smirnov Test. If the data is normally distributed, then hypothesis testing is continued using the One-Sample TTest test statistic with a significance level (α) of 0.05. The decision criteria in the test are H_0 is rejected if $t_{count} > t_{table}$ or H_0 is dismissed if the significance value (sig) <0.05.

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RESULTS AND DISCUSSION

This research produced a product in the form of a problem-based learning trigonometry module oriented to the ability to understand the concepts for 10th-grade high school students. The modules developed were structured with the principle of problem-based learning, where students were given orientation in the form of contextual problems at the beginning of learning activities. Each learning activity in the module was structured based on problem-based learning syntax, namely student orientation to issues, organizing student learning, individual and group investigations, developing and presenting work, as well as analysis and evaluation of problem-solving processes. Based on the development research the results were obtained at each stage of development using the ADDIE model, namely Analysis, Design, Development, Implementation, and Evaluation.

At the analysis stage, an analysis of the needs for the development of teaching materials, an analysis of the curriculum on trigonometric material, and an analysis of students' character were carried out. The analysis found that there was a need for teaching materials on trigonometry material so that students' mastery of concepts could be more optimal. One of the teaching materials that could be used in learning activities was a module. The module allowed students to learn actively both independently and with teacher guidance. Based on the analysis of student character, it was found that the nature of students who were the development targets followed Piaget's theory of cognitive development. These namely students were in the formal operational stage. At the proper operation stage, students can think about abstract things (Fahrurrozi & Hamdi, 2017, p. 26). At this stage, students have the possibility and opportunity to develop knowledge and understanding independently. The trigonometry material in high school learning is suitable for problem-based learning models. Many trigonometric concepts can be found in everyday life, and their application is comprehensive (Sultan & Artzt, 2011, p. 153). Thus the development of problem-based learning-based trigonometry modules can be applied to high school student learning.

At the design stage, the researcher prepared the module framework, reference books, materials, and pictures included in the module, determined the module's specification, which contained the module parts, and prepared the module assessment instrument. The assessment instruments compiled were instruments of validity, practicality, and effectiveness. The instrument of validity consisted of a validation questionnaire of material experts and media experts. Practical instruments consisted of student response questionnaires, teacher response questionnaires, and learning implementation observation sheets. Meanwhile, the effectiveness instrument was in the form of a conceptual understanding test.

At the development stage, the researcher compiled a problem-based learning trigonometry module according to the results of the design stage. After the module was completed, the module was then validated by material experts and media experts. The data from the validation results by material experts are presented in Table 10.

Table 10. Expert Material Validation Results

Scoring aspects	Average	Criteria
Content Eligibility	4.24	Very Good Validity
Module Compatibility with Problem-Based Learning Model	4.22	Very Good Validity
Average score	4.24	Very Good Validity

Based on Table 10, it was known that the assessment's average score on content feasibility and suitability with the problem-based learning model is 4.24 and 4.22, which are included in the very good validity criteria. Meanwhile, the overall assessment by material experts on the module obtained an average score of 4.24 which was also included in the outstanding validity criteria. Therefore, based on material experts' analysis of the module assessment data, the developed module is declared valid. The data from the media expert validation results are presented in Table 11.

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Table 11. Media Expert Validation Results

Scoring aspects	Average	Criteria
Presentation Eligibility	4.55	Excellent Validity
Language Eligibility	4.20	Very Good Validity
Graphic Eligibility	4.39	Very Good Validity
Average Score	4.45	Very Good Validity

Table 11 shows that the overall assessment of the module by media experts gets an average score of 4.45 which is included in the very good validity criteria. Therefore, based on the data analysis from media experts' assessment, the developed module can be declared valid. Based on the results of validation by experts, improvements to the module were also carried out according to expert advice and input so that the module was ready to be implemented in learning.

At the implementation stage, a product trial of the learning module was carried out. The trial was carried out at State Senior High School 1 Magelang with the research subjects as many as 36 students of the 10th grade MIPA 2. The practice of this product was carried out in 4 meetings with details of 3 times learning activities and one-time test of learning outcomes (post-test). Students were given a concept understanding test to determine the effectiveness of the modules used in learning. Students and teachers were also given a learning response questionnaire to determine the practicality of the module.

The final stage in developing a problem-based learning trigonometry module was the evaluation stage. At this stage, the researcher analyzed the data obtained from the results of the module trials and made revisions or improvements to the final stage based on the results of observations, input and suggestions from students and teachers during the module implementation process in school learning.

The student response questionnaire data analysis results showed the aspects of presentation, content, language, graphics, and benefits. The data recapitulation of the results of the student response questionnaire analysis is presented in Table 12.

Table 12. Student Response Questionnaire Results

Scoring aspects	Average	Criteria
Presentation	3.92	Rather Practical
Content	3.93	Rather Practical
Language	4.00	Practical
Graphics	3.80	Rather Practical
Benefits	4.07	Practical
Average score	3.93	Rather Practical

Table 12 shows that the overall average score of the student response questionnaire data gets a score of 3.93 which is included in the rather practical criteria. Thus the developed module fulfils the practical aspect. The data from the teacher's response questionnaire are presented in Table 13.

Table 13. Teacher Response Questionnaire Results

Scoring aspects	Average	Criteria
Presentation	4.00	Practical
Content	4.00	Practical
Language	4.00	Practical
Graphics	4.00	Practical
Benefits	4.00	Practical
SkorRata-rata	4.00	Practical

Table 13 shows that the overall average score of the teacher response questionnaire data gets a score of 4.00 which is included in the practical criteria. Thus the module developed was declared applicable. Meanwhile, to determine the level of implementation of the problem-based learning model, data analysis of the learning implementation observation sheet was carried out. The learning implementation observation sheet data are presented in Table 14.

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Table 14. Results of Observation of Learning Implementation

Meeting	Implement ability Percentage
1	85.7
2	100
3	100
Average	95.24

Based on Table 14, the average percentage of learning implementation is 95.24%. This shows that learning by using the module goes well.

The concept of understanding test data was used to determine the effectiveness of the developed module. 33 students carried out the concept understanding test. Based on the conceptual understanding test results, the student's average score was 80.72, including high criteria. If each student's score is compared with the school's Minimum Completeness Criteria (KKM), which is 70, then 29 students have completed it. Four students have not completed, so the percentage of student learning completeness is 87.88%, which is included in the very good criteria in Table 6. Recapitulation of test result data and understanding of the concept is presented in Table 15.

Table 15. Recapitulation of Concept Understanding Test Results

Information	Test Result
Number of students who took the test	33
Highest Score	98
Lowest Score	45
Standard Deviation	12.47
Number of Students Passed the Test	29
Number of Students Failed the Test	4
Average	80,72
Percentage of Completeness	87,88

The hypothesis testing of the effectiveness of the learning module was carried out on the data on the results of the student's conceptual understanding test which was presented in Table 15. The developed module is declared effective if the average student's conceptual understanding is more than 70. Before testing the hypothesis, the assumption of normality must be met first. Normality testing was carried out with the help of SPSS with the One-Sample Kolmogorov-Smirnov Test. From the test results, a significance value of 0.10 > 0.05 was obtained, so it could be concluded that the concept of understanding test data was normally distributed.

After the assumption of normality was met, the next step was to test the effectiveness of the learning module in terms of students' conceptual understanding ability. H_0 is rejected if $t_{count} > t_{table}$ or H_0 is rejected if the significance value is less than the significance level (α) of 0.05. Based on the test results with SPSS, the values of t_{count} = 4.94 and t_{table} = 1.694 with degrees of freedom df = 32. Because $t_{count} >> t_{table}$, then H_0 is rejected, and H_1 is accepted. The recapitulation of the test results is presented in Table 16.

Table 16. T-Test Test Results

t	df	$Sig.(2{-}tailed)$
4,940	32	0,000

Based on the results of hypothesis testing in Table 16, the value of $sig(2 - tailed)$ is 0.000. Therefore, a significance value (sig) of 0.000/2 = 0.000 < 0.05 was obtained. According to the decision criteria, H_0 was rejected, and H_1 was accepted so the average student concept understanding ability was more than 70. Thus, it can be concluded that problem-based trigonometry module-based learning is effective in terms of students' conceptual understanding abilities.

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Discussions

The results showed that the problem-based learning trigonometry module got a good response from students and teachers. The modules developed had good quality because they met valid, practical, and effective criteria. This is in line with the findings of previous studies (e.g. Anggraini, 2019; Citroresmi & Suratman, 2016; Setyadi & Saefudin, 2019). The problem-based learning trigonometry module could be used as an alternative teaching material for high school mathematics learning to develop students' conceptual understanding abilities.

Based on the module's validity assessment through a material expert and media expert validation questionnaire, the module developed was declared valid. The learning modules designed were compiled based on the development guidelines and principles of learning textbooks used in education units as stated in the Regulation of the Minister of Education and Culture Number 8 of 2016 concerning Books Used by Education Units (Kemendikbud, 2016). Meanwhile, the material presented in the module was based on the standard content of the 2013 Curriculum as stated in the Regulation of the Minister of Education and Culture Number 37 of 2018 concerning Core Competencies and Basic Competencies in the 2013 Curriculum in Primary and Secondary education (Kemendikbud, 2018) and referred to various mathematics textbooks. Thus, it could be concluded that the module developed was valid following the standard of learning textbooks by the Ministry of Education and Culture.

Based on the assessment of the practicality of the module through student and teacher response questionnaires, the developed module was declared practical. The fulfilment of this practicality indicated that students and teachers could easily use and utilize the module in learning activities (Nieveen, 1999, p. 127). This is in line with the findings of previous studies, which stated that the mathematics module with a problem-based learning model received a good response from students(Anggraini, 2019; Citroresmi & Suratman, 2016). The module format in the form of a soft file also makes it easier for students and teachers to access it through smartphones or other electronic media. Thus, it could be concluded that the module developed was practical and easy to use by students and teachers in learning.

The effectiveness of the learning module based on the results of the analysis of the conceptual understanding test showed that the developed module met the criteria for effectiveness. The average ability to understand concepts obtained by students was 80.72, which is included in the high standards. Meanwhile, the percentage of classical learning completeness was 87.88, which, based on Table 6, is included in the very good criteria. The results of hypothesis testing on students' concept understanding test data obtained a significance value of less than 0.05, concluding that the average student concept understanding ability was more than 70. Thus, the problem-based learning trigonometry module developed was declared effective in students' conceptual understanding abilities.

The effectiveness of this learning module was because the modules developed were arranged according to the principles and characteristics of the problem-based learning model. The module product was prepared by applying the principle of meaningful learning involving students actively finding learning concepts. This is in line with Setyadi & Saefudin (2019) research, which stated that problem-based learning models provided opportunities for students to discuss solving problems so that learning became meaningful and could develop students' understanding of learning materials. Student activity sheets in modules that were arranged based on problem-based learning syntax provided facilities for students to discuss in groups. Good concept understanding could be facilitated through group discussions (Schunk, 2012, p. 271). This gives students a good learning experience so it could train them to understand the concepts of learning materials.

CONCLUSION

The problem-based learning trigonometry module that is oriented to the ability to understand concepts for class X high school students was developed using the ADDIE development model. The quality of the problem-based learning-based trigonometry module developed is as follows. *First*, the problem-based learning trigonometry module is declared valid based on material and media expert assessments. The results of the module assessment by material experts got an average score of 4.24 which is included in the very good validity criteria. The module assessment by media experts got an average score of 4.45 which is included in the very good validity criteria. *Second*, the problem-based learning-based trigonometry module is stated as practical based on student and teacher response questionnaires. The assessment results on the student response questionnaire got an average score of

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3.93 which is included in the criteria for being rather practical. The teacher's response questionnaire assessment got an average score of 4.00 which is included in the applicable criteria.

Meanwhile, based on the observation sheet on the implementation of learning, the average implementation of problem-based learning was 95.24. *Third*, the problem-based learning-based trigonometry module is declared effective in terms of the conceptual understanding test. Based on the conceptual understanding test results, the average score obtained by students was 80.72, which is included in the high criteria. Meanwhile, based on hypothesis testing using a t-test with a significance level of 0.05, it was obtained that the average student concept understanding ability was more than 70.

This research and development have limitations; namely, the material presented in the module is limited to only the sine and cosine rules. In addition, the research subject at the product trial stage is limited to one class from one school, so it needs to be implemented more comprehensively. The suggestions include the results of module products. It can be used as an alternative material for high school mathematics learning. In addition, the results of research on module development can be used as a reference for teachers or educators in developing teaching materials on other mathematics materials, as well as for further researchers to improve the module both in terms of presentation and content of learning materials.

REFERENCE

Anggraini, L. D. F. (2019). Geometri fraktal dan transformasi geometri sebagai dasar pengembangan motif batik sekar jagad. *Transformasi : Jurnal Pendidikan Matematika Dan Matematika*, *3*(1), 1–14. https://doi.org/10.36526/tr.v3i1.384

Azis, A., & Sugiman, S. (2015). Analisis kesulitan kognitif dan masalah afektif siswa SMA dalam belajar matematika menghadapi ujian nasional. *Jurnal Riset Pendidikan Matematika*, *2*(2), 162–174. https://doi.org/10.21831/jrpm.v2i2.7331

Bussi, M. G. B., & Borba, M. C. (2010). The role of resources and technology in mathematics education. *ZDM - International Journal on Mathematics Education*, *42*(1), 1–4. https://doi.org/10.1007/S11858-010-0234-0/METRICS

Citroresmi, N., & Suratman, D. (2016). Pengembangan modul matematika berbasis masalah untuk meningkatkan kemampuan penyelesaian masalah dan berpikir kreatif matematis siswa. *Jurnal Pendidikan Dan Pembelajaran Khatulistiwa (JPPK)*, *5*(4). https://doi.org/10.26418/JPPK.V5I4.14866

Delisle, R. (1997). *How to use problem-based learning in the classroom*. Association for Supervision and Curriculum Development.

Dick, W., & Carey, L. (1996). *The systematic design of instruction* (4th ed.). Harper Collins College Publishers.

Fahrurrrozi, & Hamdi, S. (2017). *Metode pembelajaran matematika*. Universitas Hamzanwadi Press.

Kemendikbud. (2014). *Peraturan menteri pendidikan dan kebudayaan republik Indonesia nomor 58, tahun 2014, tentang kurikulum 2013 sekolah menengah pertama/ madrasah tsanawiyah*. Kementerian Pendidikan dan Kebudayaan Republik Indonesia.

Kemendikbud. (2016). *Peratutan menteri pendidikan dan kebudayaan nomor 8, tahun 2016, tentang buku yang digunakan oleh satuan pendidikan*. Kementerian Pendidikan dan Kebudayaan Republik Indonesia.

Kemendikbud. (2018). *Peraturan menteri pendidikan dan kebudayaan republik indonesia nomor 37, tahun 2018 tentang kompetensi inti dan kompetensi dasar pelajaran pada kurikulum 2013 pada pendidikan dasardanpendidikan menengah*. Kementerian Pendidikan dan Kebudayaan Republik Indonesia.

Kemendikbud. (2019). *Pusat penilaian pendidikan: capaian nasional*. Kementerian Pendidikan dan Kebudayaan Republik Indonesia.

Lasmiyati, & Harta, I. (2014). Pengembangan modul pembelajaran untuk meningkatkan pemahaman konsep dan minat SMP. *Pythagoras: Jurnal Matematika Dan Pendidikan Matematika*, *9*(2), 161–174. https://doi.org/10.21831/PG.V9I2.9077

NCTM. (2017). *Executive summary principles and standards for school mathematics*. The National Council of Teachers of Mathematics.

Nelfiyanti, & Sunardi, D. (2017). Penerapan metode problem based learning dalam pelajaran Al-Islam II di Fakultas Teknik Universitas Muhammadiyah Jakarta. *Spektrum Industri*, *15*(1), 111–119. https://doi.org/10.12928/si.v15i1.6185

Nieveen, N. (1999). Prototyping to reach product quality. In *Design Approaches and Tools in Education and Training* (pp. 125–135). Springer Netherlands. https://doi.org/10.1007/978-94-011-4255-7_10

OECD. (2019). *PISA 2018 results combined executive summaries volume I,II,III*. Organization for Economic Co-operation and Development.

Pane, A., & Dasopang, M. D. (2017). Belajar dan pembelajaran. *FITRAH:Jurnal Kajian Ilmu-Ilmu Keislaman*, *3*(2), 333–352. https://doi.org/10.24952/fitrah.v3i2.945

Santika, F., Sowiyah, Pangestu, U., & Nurahlaini, M. (2021). School facilities and infrastructure management in improving education quality. *International Journal of Research and Innovation in Social Science*, *05*(06), 280–285. https://doi.org/10.47772/IJRISS.2021.5612

Schunk, D. H. (2012). *Learning Theories an Educational Perspective* (Vol. 6th). Pearson.

Setyadi, A., & Saefudin, A. A. (2019). Pengembangan modul matematika dengan model pembelajaran berbasis masalah untuk siswa kelas VII SMP. *Pythagoras: Jurnal Pendidikan Matematika*, *14*(1), 12–22. https://doi.org/10.21831/pg.v14i1.16771

Sudjana, D. N. (2019). *Penilaian Hasil Proses Belajar Mengajar*. PT Remaja.

Sugiyono. (2018). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Alphabeta Publisher.

Sultan, A., & Artzt, A. F. (2011). *The Mathematics that Every Secondary Math Teacher Needs to Know*. Routledge.

Sutawidjaja, A., & Afgani, J. (2014). *Konsep Dasar Pembelajaran Matematika*. Universitas Terbuka.

Woolfolk, A. (2016). *Educational Physicology*. Pearson Education.

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